NuScale Power™

RAIO-0118-58484

January 31, 2018

Docket No. 52-048

U.S. Nuclear Regulatory Commission
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11555 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 244 (eRAI No. 9013) on the NuScale Design Certification Application

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 244 (eRAI No. 9013)," dated September 29, 2017
2. NuScale Power, LLC Response to NRC Request for Additional Information No. 244 (eRAI No. 9013)on the NuScale Design Certification Application

The purpose of this letter is to provide the NuScale Power, LLC (NuScale) response to the referenced NRC Request for Additional Information (RAI).

The Enclosures to this letter contain NuScale's response to the following RAI Questions from NRC eRAI No. 9013:

- 09.01.02-32
- 09.01.02-33
- 09.01.02-34
- 09.01.02-35

The response to RAI Questions 09.01.02-29, 09.01.02-30 and 09.01.02-31 were previously provided in Reference 2. This completes all responses to eRAI 9013.

Enclosure 1 is the proprietary version of the NuScale Response to NRC RAI No. 244 (eRAI No. 9013). NuScale requests that the proprietary version be withheld from public disclosure in accordance with the requirements of 10 CFR § 2.390. The enclosed affidavit (Enclosure 3) supports this request. Enclosure 2 is the nonproprietary version of the NuScale response.

This letter and the enclosed responses make no new regulatory commitments and no revisions to any existing regulatory commitments.

If you have any questions on this response, please contact Carrie Fosaaen at 541-452-7126 or at cfosaaen@nuscalepower.com.

Sincerely,

Zackary W. Rad
Director, Regulatory Affairs
NuScale Power, LLC

Distribution: Gregory Cranston, NRC, OWFN-8G9A
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Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 9013, proprietary

Enclosure 2: NuScale Response to NRC Request for Additional Information eRAI No. 9013, nonproprietary

Enclosure 3: Affidavit of Zackary W. Rad, AF-0118-58485

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 9013, proprietary

Enclosure 2:

NuScale Response to NRC Request for Additional Information eRAI No. 9013, nonproprietary

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Response to Request for Additional Information
Docket No. 52-048

eRAI No.: 9013
Date of RAI Issue: 09/29/2017

NRC Question No.: 09.01.02-32

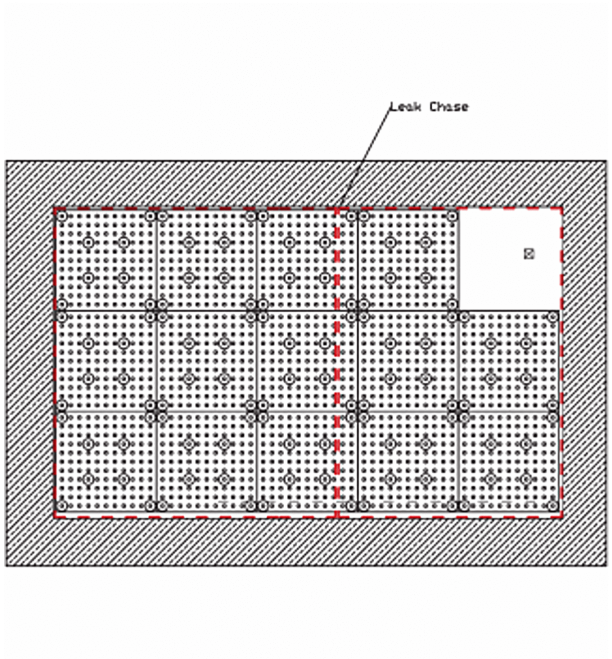
10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10 CFR 52.80(a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. SRP Sections 9.1.2 and DSRS Sections 3.8.4 Appendix D describe the specific SRP acceptance criteria for the review of the fuel racks to meet the requirements of the Commission's regulations identified above.

The applicant should explain the design evaluations for the loads imparted on the pool liner and concrete floor immediately below the rack legs. The applicant should address if the rack leg bearing plates were properly sized to avoid crushing the concrete in the localized region. The applicant should also explain whether the rack legs, including the bearing plates, are designed to avoid damaging the leak chase channels, and describe whether the rack legs and leak chase channels are located in positions to avoid the rack leg impact forces on the leak chase channels. The applicant should describe whether rack movement due to seismic displacement of the racks is also considered in this evaluation.

NuScale Response:

Evaluations were performed to determine stresses in the liner plate and concrete underlying the spent fuel rack legs under maximum leg loading. The demand-capacity ratio of the liner stress under these conditions is 0.08. The design-capacity ratio of concrete punching shear is 0.07. The design-capacity ratio of concrete bearing is 0.44. Since these are all less than 1.0, they are acceptable and demonstrate sufficient margin for the liner and concrete beneath the spent fuel rack and indicate that the rack bearing plates are properly sized.

The leak chase system was laid out in such a way as to avoid being beneath the fuel rack legs, when the racks are initially placed, as depicted in the general arrangement sketch below. Because of the closely spaced arrangement of the racks, it cannot be guaranteed that a rack leg will not end up directly on top of a leak chase channel after seismic displacement of the racks. However, due to the bearing plate design, the liner stress is so low, even for maximum loading conditions, the leak chase system bears no risk of being damaged.



Impact on DCA:

There are no impacts to the DCA as a result of this response.

Response to Request for Additional Information
Docket No. 52-048

eRAI No.: 9013
Date of RAI Issue: 09/29/2017

NRC Question No.: 09.01.02-33

10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10 CFR 52.80(a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. SRP Sections 9.1.2 and DSRS Sections 3.8.4 Appendix D describe the specific SRP acceptance criteria for the review of the fuel racks to meet the requirements of the Commission's regulations identified above.

The staff reviewed the results of the sensitivity analysis from the partially loaded fuel racks. The staff noted that starting in section 3.1.6.6.5, it appears that in a number of cases significantly higher forces result from the partially loaded rack analysis. Several of these specific cases are referenced below. The staff requests the applicant provide additional information to justify these increased forces.

a. On Page 225 of the TR, the applicant states that the baseplate force is higher for the partially loaded rack analysis than the fully loaded rack results. The applicant further states, "The increase forces are due to rack-to-rack impact and that the increased force does not affect the qualification of the baseplate because it is in the strong direction of the plate." The applicant should provide justification for why the qualification of the baseplate is acceptable.

b. On page 226 of the TR, the applicant states that the highest contact force between rack baseplates and adjacent exterior faces for the partially loaded rack is higher than fully loaded rack results (X- direction, baseplate of Rack#13 to exterior wall of Rack #14). The applicant further states, "The increased forces are due to increased rack-to-rack impact; however, the fully loaded analyses have demonstrated that impact loadings are negligible compared to the effect of water pressure on the outside of the bottom grid, bottom band, and fuel tubes." The applicant should quantify the contact force in relation to the effect of water pressure to demonstrate the negligible effect of impact loadings.

c. On page 228 of the TR, the applicant states, "The highest lateral baseplate forces are 91 percent higher than the fully loaded analysis results." The applicant should provide additional information to demonstrate that although lateral baseplate forces are 91% higher, the IR is only 3% higher than the fully loaded results (based on the IR presented in Table 3-62 versus Table 3-33).

d. On page 225, of the TR, the applicant stated that the peak vertical force for the fuel storage

rack legs is higher than fully loaded rack results (Rack #15); however, this value is enveloped by the maximum leg force as determined in Section 3.1.3." Section 3.1.3 of the report addresses the FA drop impact load which does have a higher impact force; however, it also has a higher allowable stress for the rack leg because this is an accidental drop load case. The applicant should explain why the comparison is not made to the Level D stress allowable, as described on page 190 of the report.

e. In addition, for any additional results where the forces are found to be higher for the partially loaded rack analysis, the applicant should provide additional justification to demonstrate that the fuel storage racks are designed with sufficient margin to withstand these increased forces.

NuScale Response:

Response to 09.01.02-33.a

The fuel storage rack baseplate {{

.}} 2(a), (c). Baseplate-to-baseplate impact or contact loads result in in-plane loads on the baseplate. The effect of this "lateral" load on the connected members (i.e., the distribution of the in-plane load from the baseplate tofuel assembly tubes) is addressed by separate investigations of the stresses within those connected members. However, a specific check of the baseplate itself for these in-plane loads is not deemed necessary, since the plate cannot buckle. Such contact loadings will result in local deformation/crushing of the baseplate at the point of contact, however, this is considered acceptable for design-basis seismic loadings. Out-of-plane (i.e., "vertical" loads) on the baseplate are investigated and compared to appropriate code-specified allowable stresses.

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}} 2(a), (c)

Response to 09.01.02-33.b

The statement on page 226 of TR-0816-49833-P: “The increased forces are due to increased rack-to-rack impact; however, the fully loaded analyses have demonstrated that impact loadings are negligible compared to the effect of water pressure on the outside of the bottom grid, bottom band, and fuel tubes” was a mis-statement as written and was corrected. The design of the fuel storage racks is completed using the results from the whole pool analysis. No single load is used in the design of the fuel storage rack. It is completed with a combination of static and time-variable loads (dead, hydrostatic, seismic, including hydrodynamic, rack-to-rack impacts, fuel assembly-to-rack impacts, etc.) on a rack through time (see the response to Question 09.01.02-30 of RAI 9013 for detailed explanation of design selection process). The individual contributing loads present in the highly nonlinear whole pool analysis are difficult to truly separate to the point that each load can be algebraically summed together for design. As described in the response to Question 09.01.02-30 of RAI 9013, several parameters that could be extracted were chosen to provide a criteria for design selection. Therefore, to demonstrate how the various loads seen during the whole pool analysis affect the overall design, a single rack is selected to compare the magnitude of loads and the corresponding interaction ratios (IRs) of the major components. To provide an example, Rack 14 is examined. Rack 14 was selected for design using TH1 (coefficient of friction = 0.2) (see RAI 9013 Response to Question 09.01.02-30) and experienced allowable stress exceedance from rack-to-adjacent-exterior-face impact from partially loaded sensitivity study case 1. The selection criteria parameters are shown in the table below to demonstrate and compare magnitudes of whole pool analysis loads experienced by Rack #14 besides rack-to-exterior-face impact, as well as final design IRs of various components. The IRs presented for TH1 Rack 14 do not represent all the controlling values for the total rack design. They are IRs obtained for Rack 14 only. The final, controlling IRs come from the maximums obtained from all the design cases described in RAI 9013 Response to Question 09.01.02-30.

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}} 2(a), (c)

The table above demonstrates that, although the maximum values from various impacts increase for Rack 14, the percentage increase in IRs between Partially Loaded Case 1 and TH1 Low Friction case is far less. It also shows the Rack 14 TH1 results had higher accelerations than those of Partially Loaded Case 1, which affect the IRs. This table demonstrates that the design of the fuel storage racks is based on the combination of several load types, and that impact loads, while contributing to the final design stresses, only represent one portion of the

design loads.

The table below compares the estimated hydrodynamic forces acting on Rack 14 from both the TH1 low friction case and Partially Loaded Case 1 with the impact forces seen by Rack 14 due to the impact of Rack 13 baseplate to Rack 14 exterior face. This hydrodynamic force is the summation of the water pressure times contact area of each of the water elements in contact with one exterior face of Rack 14. The peak hydrodynamic force is compared to the baseplate-to-Rack-14-exterior-face impact force at the time point the maximum hydrodynamic force occurs. Conversely, the same forces are compared when the peak baseplate-to-Rack-14-exterior-face impact occurs. Additionally, the time points at which the maximum IR for the bottom band occur (component with the exceedance described in Section 3.1.6.7 of TR-0816-49833-P) have their respective hydrodynamic and impact forces compared.

Analysis Case	Time Point (seconds)	Time Event Description	Water Force on Rack 14 (lbs)	Rack 13 Baseplate to Rack 14 Wall Force (lbs)
Partially Loaded Rack Case 1	14.025	Peak Hydrodynamic Force	409,296	136,832
	15.995	Peak Baseplate-to-Rack- Exterior Face Force	58,104	297,229
	19.45	Peak IR of 0.90	225,958	254,048
TH1 Low Friction	14.55	Peak Water Load	349,321	16,479
	13.78	Peak Baseplate-to-Rack- Wall Force	77,631	84,725
	18.075	Peak IR of 0.73	326,799	0

The table above demonstrates that the peak hydrodynamic forces are higher than impact forces. Additionally, hydrodynamic forces are generally of longer duration and, thus, more of a sustained load rather than a sharp impact. The table above also demonstrates that peak loads incurred during the whole pool analyses occur at differing time points, such that the IR contribution to the final design IRs cannot be linearly extrapolated. Therefore, any exceedance that was discovered was run through the design process shown in Section 3.1.6.7.3 of TR-0816-49833-P to ensure components maintained sufficient design margin.

The text in Section 3.1.6.6.5 of TR-0816-49833-P: “The increased forces are due to increased rack-to-rack impact; however, the fully loaded analyses have demonstrated that impact loadings are {{

}}[2(a), (c)]” was corrected to read: “The increased forces are due to increased rack-to-rack impact. Design checks demonstrate sufficient design margin is available to accommodate the increase in contact force (see Section 3.1.6.7.3).”

Response to 09.01.02-33.c

The IR value reported for the baseplate, in both the fully loaded analysis and the partially loaded analysis, are not related to the in-plane (i.e., “lateral”) loads on the rack baseplate. The increased IR results from slightly higher out-of-plane (i.e., “vertical”) loads on the rack baseplate found in the partially loaded analysis. The design of each component is performed for the complete loading seen in the whole pool analysis, which includes dead, seismic, hydrostatic, hydrodynamic, and impact loads. See also response to RAI 9013, Question 09.01.02-33(a) for justification as to why the reported IR is not dependent on the baseplate in-plane loads.

Response to 09.01.02-33.d

Comparison of the peak vertical force for the fuel storage rack legs against Level D stress allowable was performed. The peak vertical force from the partially loaded sensitivity analyses was {{ }}$^{2(a), (c)}$ greater than the fully loaded rack results. Where the fully loaded rack leg stress calculations, shown in Section 3.1.5.5.3 of TR-0816-49833-P, did not provide margin greater than or equal to {{ }}$^{2(a), (c)}$ by simple visual examination, such as in cases of combined axial and bending (vertical load increases but horizontal load decreases slightly), checks were conducted using the increased peak vertical force, along with the associated horizontal force, to ensure Level D stress allowables were not exceeded. The support leg stress calculations in Section 3.1.5.5.3 of the TR-0816-49833-P were repeated using the increased vertical force (note that Section 3.1.5.5.3 was updated per response to Question 09.01.02-35 of RAI 9013. See the response provided for the updated stress checks.). The evaluations described in the following text show that sufficient margin was maintained with the increased vertical leg force.

The statement in the TR under Section 3.1.6.6.4: “…is {{

}}$^{2(a), (c)}$ as determined in Section 3.1.3.” was replaced with “The peak vertical force for the fuel storage legs is {{ }}$^{2(a), (c)}$ higher than the fully loaded rack results (Rack 15). Many of the individual components and welds of the foot evaluated in Section 3.1.5.5.3 were shown to have greater than {{ }}$^{2(a), (c)}$ margin by simple inspection. Those components with combined forces and moments that could not be simply determined to have sufficient margin were re-evaluated and shown to have sufficient margin.”

The higher vertical and corresponding horizontal loads were utilized in the calculations that follow. All calculated section properties, allowables, and dimensions used in Section 3.1.5.5.3 remained the same and, therefore, were not recalculated here.

- Cylindrical portion of screw block combined axial & bending stress

Compression

Area available: $A_h = 12.37\ \mathrm{in}^2$

Axial stress: $f_a = (200.249\ \mathrm{kip}) / 12.37\ \mathrm{in}^2 = 16.19\ \mathrm{ksi}$

Bending

Moment: $M_b = 4.62\ \mathrm{in} \times 54.898\ \mathrm{kip} = 253.63\ \mathrm{kip} * \mathrm{in}$

Bending Stress: $f_b = \frac{253.63\ kip\ in}{6.282\ in^3} = 40.37\ ksi$

Check of Combined Axial and Bending:

$$F_e = \frac{\pi^2 \times E}{1.3 \times (k \times \frac{l_b}{r_b})^2} = \frac{\pi^2 \times 27.44 \times 10^3 ksi}{1.3 \times (2.1 \times \frac{3.0\ in}{1.008\ in})^2} = 5.331 \times 10^3\ ksi$$

Therefore, $\frac{f_a}{F_a} + \frac{C_{mx} \times f_{bx}}{(1 - \frac{f_a}{F_{ex}}) \times F_{bx}} = \frac{16.19\ ksi}{43.29\ ksi} + \frac{0.85 \times 40.37\ ksi}{\left(1 - \frac{16.19}{5.331 \times 10^3}\right) \times 86.75\ ksi} = 0.77 \leq 1.0 \rightarrow OK$

$$\frac{f_a}{2 \times 0.6 S_y} + \frac{f_{bx}}{F_{bx}} = \frac{16.19\ ksi}{2 \times 0.6 \times 51.18\ ksi} + \frac{40.37\ ksi}{86.75\ ksi} = 0.73 \leq 1.0 \rightarrow OK$$

$$\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} = \frac{16.19\ ksi}{43.29\ ksi} + \frac{40.37\ ksi}{86.75\ ksi} = 0.84 \leq 1.0 \rightarrow OK$$

- Thread Shear Stress

Shear stress due to F_H: $f_{v1} = \frac{200.249\ \mathrm{kip}}{27.51\ \mathrm{in}^2} = 7.28\ \mathrm{ksi}$

Shear stress due to Moment: $f_{v2} = \frac{253.63\ \mathrm{kip\ in} \times D_k \times 0.5}{416.73\ \mathrm{in}^4} = 1.18\ \mathrm{ksi}$

Total shear: $f_v = f_{v1} + f_{v2} = 8.46\ ksi$

Allowable shear: $F_v = \min(0.72S_y, 0.42S_u) = \min(36.85\ \text{ksi},\ 35.58\ \text{ksi})$

$= 35.58\ \text{ksi} > 8.46\ \text{ksi}\ \rightarrow \text{OK}$

- Thread bending stress

Moment: $M_{b\_local} = (8.46\ \text{ksi}\ \times 1\ \text{in}\ \times 0.0625\ \text{in}) \times 0.02708\ \text{in} = 14.32 \times 10^{-3}\ \text{kip} * \text{in}$

Bending Stress: $f_{b\_local} = \frac{14.32\times10^{-3}\ \text{kip in}}{\frac{1\ in \times (0.0625\ in)^2}{6}} = 22.00\ ksi$

Allowable Bending Stress: $F_b = f \times\ S_y = 1.5 \times 51.18\ ksi = 76.77\ ksi\ > 22.00\ ksi\ \rightarrow OK$

- Baseplate shear stress & bending stress

Moment: $M_b = 7.35\ \text{in}\ \times 54.898\ \text{kip} = 403.5\ \text{kip} * \text{in}$

Shear stress: $f_v = \frac{200.249\ \text{kip}}{29.34\ \text{in}^2} + \frac{403.5\ \text{kip}*\text{in}}{68.52\ \text{in}^3} = 6.83\ \text{ksi} + 5.89\ \text{ksi} = 12.72\ \text{ksi}$

Allowable shear: $F_v = 33.55\ \text{ksi}\ \ > 12.72\ \text{ksi}\ \rightarrow \text{OK}$

Moment: $M_{b\_local} = (12.72\ \text{ksi}\ \times 1\ \text{in}\ \times 1\ \text{in}) \times \frac{(9.34in-7.84in)\times0.5}{2} = 4.77\ \text{kip} * \text{in}$

Bending Stress: $f_{b\_local} = \frac{4.77\ kip\ in\ \times(1in\times0.5)}{\frac{1\ in \times (1\ in)^3}{12}} = 28.62\ ksi$

Allowable Bending Stress: $F_b = 37.05\ \ ksi\ \ > 28.62\ ksi\ \rightarrow OK$

- Support tube combined axial & bending stress

<u>Compression</u>

Area available: $A_h = 16.115\ \text{in}^2$

Axial stress: $f_a = (200.249\ \text{kip})\ /\ 16.115\ \text{in}^2 = 12.43\text{ksi}$

Bending

Moment: $\mathrm{M_b} = 7.35\ \mathrm{in}\ \times 54.898\ \mathrm{kip} = 403.50\ \mathrm{kip} * \mathrm{in}$

Bending Stress: $f_b = \frac{403.50 \times 8.59 \times 0.5\ kip\ in}{149.87\ in^3} = 11.56\ ksi$

Check of Combined Axial and Bending:

$$F_e = \frac{\pi^2 \times E}{1.3 \times (k \times \frac{l_b}{r_b})^2} = \frac{\pi^2 \times 27.44 \times 10^3 ksi}{1.3 \times (1.2 \times \frac{2.5\ in}{3.05 in})^2} = 2.153 \times 10^5\ ksi$$

Therefore, $\frac{f_a}{F_a} + \frac{C_{mx} \times f_{bx}}{(1 - \frac{f_a}{F_{ex}}) \times F_{bx}} = \frac{12.43\ ksi}{41.61\ ksi} + \frac{0.85 \times 11.56\ ksi}{\left(1 - \frac{12.43}{2.153 \times 10^5}\right) \times 59.55\ ksi} = 0.46 \le 1.0\ \rightarrow OK$

$$\frac{f_a}{2 \times 0.6 S_y} + \frac{f_{bx}}{F_{bx}} = \frac{12.43\ ksi}{2 \times 0.6 \times 46.6\ ksi} + \frac{11.56\ ksi}{59.55\ ksi} = 0.42 \le 1.0 \rightarrow OK$$

$$\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} = \frac{12.43\ ksi}{41.61\ ksi} + \frac{11.56\ ksi}{59.55\ ksi} = 0.49\ \le 1.0\ \rightarrow OK$$

- Weld stress between support tube and weld block

Moment: $\mathrm{M_b} = 5.85\ \mathrm{in}\ \times 54.898\ \mathrm{kip} = 321.15\ \mathrm{kip} * \mathrm{in}$

Calculate the weld stress:

Vertical stress is from the vertical force plus the moment:

$$f_v = \frac{200.249\ kip}{19.13\ in} + \frac{321.15\ kip\ in \times 3.92\ in}{146.58\ in^3} = 19.06\ \frac{ksi \times in}{\text{inch of weld}}$$

Horizontal stress is from the horizontal force:

$$f_h = \frac{54.898\ kip}{19.13\ in} = 2.87\ \frac{ksi \times in}{\text{inch of weld}}$$

Resultant stress:

$$f_r = \sqrt{{f_v}^2 + {f_h}^2} = \sqrt{19.06^2 + 2.87^2} = 19.28\frac{ksi \times in}{\text{inch of weld}}$$

Thus for ¾" weld:

$$f_r = \frac{19.28\ ksi \times in}{{}^3/_4 in} = 25.71\ ksi$$

Compare with the allowable strength:

$$F_b = 31.67\ ksi\ > 25.71\ ksi\ \rightarrow OK$$

- Weld stress between support tube and baseplate

Moment: $\mathrm{M_b} = 7.35\ \mathrm{in}\ \times 54.898\ \mathrm{kip} = 403.50\ \mathrm{kip} * \mathrm{in}$

Calculate the weld stress:

Vertical stress is from the vertical force plus the moment:

$$f_v = \frac{403.50\ kip\ in \times 4.67\ in}{259.59\ in^3} = 7.26\ \frac{ksi \times in}{\text{per inch of weld}}$$

Horizontal stress is from the horizontal force:

$$f_h = \frac{54.898\ kip}{23.84\ in} = 2.30\frac{ksi \times in}{\text{inch of weld}}$$

Resultant stress:

$$f_r = \sqrt{{f_v}^2 + {f_h}^2} = \sqrt{19.06^2 + 2.87^2} = 19.28\frac{ksi \times in}{\text{inch of weld}}$$

Thus for ½" weld:

$$f_r = \frac{7.62\ ksi \times in}{{}^{1}/_{2} in} = 15.24\ ksi$$

Compare with the allowable strength:

$$F_b = 16.8\ ksi\ > 15.24\ ksi\ \rightarrow OK$$

Response to 09.01.02-33.e

Section 3.1.6.6 of the TR-0816-49833-P compares the loads experienced on fully filled racks with extreme coefficient of friction (COF) values between the feet and liner versus partially filled racks with varying COF values between feet and liner to identify any racks that experience increased loads in the partially filled configuration. Section 3.1.6.7 of TR-0816-49833-P reports the results of the evaluation of the increased loads in the partially filled racks. As described in response to RAI 9013, Question 09.01.02-30, racks were identified for detailed design analysis based on selection criteria associated with maximum loads. Similarly, racks that experienced increased loads in the partially filled configuration were selected for detailed design analysis, documented in Section 3.1.6.7 of TR-0816-49833-P. Because the increased loads occurred in specific rack components (e.g., increased vertical load of the baseplate of Rack 8), the detailed analysis was only performed for the affected component. The detailed analyses of these components, similar to the analysis performed on the entire rack in Section 3.1.5.5.3 of TR-0816-49833-P, demonstrate that the increased partially filled rack loads are acceptable.

Impact on DCA:

Technical Report TR-0816-49833, Fuel Storage Rack Analysis, has been revised as described in the response above and as shown in the markup provided in this response.

compared to the analyses with fully loaded racks in Table 3-56. Minimum remaining gap between racks and the SFP walls for both Case 1 and Case 2 is greater than the fully loaded rack results. No contact occurs between the racks and the SFP walls. This indicates that there is less sliding and tipping toward the SFP walls.

Table 3-56 Comparison of remaining gap between racks and spent fuel pool walls

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}}2(a),(c)

3.1.6.6.4 Maximum Floor Reaction Under One Leg

Section 3.1.6.5.7 and Section 3.1.6.5.8 list the maximum forces under one leg (vertical reaction and friction) for each fuel storage rack for the partially loaded whole-pool analysis (Case 1 and Case 2). The maximum leg forces are summarized and compared to the analyses with fully loaded racks in Table 3-57. Peak lateral forces are enveloped by fully loaded rack results. The peak vertical force for the fuel storage rack legs is {{ }}2(a),(c) higher than fully loaded rack results (Rack 15). Many of the individual components and welds of the foot evaluated in Section 3.1.5.5.3 were shown to have greater than {{ }}2(a),(c) margin by simple inspection. Those components with combined forces and moments that could not be simply determined to have sufficient margin were re-evaluated and shown to have sufficient margin.fuel storage rack legs is {{ }}2(a),(c) as determined in Section 3.1.3.

Table 3-57 Comparison of maximum fuel storage rack leg forces

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}}2(a),(c)

3.1.6.6.5 Rack-to-Rack Contact Forces

Section 3.1.6.5.9 lists the contact forces between adjacent racks for the partially loaded whole-pool analysis (Case 1 and Case 2). The maximum baseplate forces are summarized and compared to the analyses with fully loaded racks in Table 3-58. {{ }}2(a),(c) (X-direction, Rack #13). The increased forces are due to increased rack-to-rack impact; however, an increase in lateral force does not affect the qualification of the baseplate because it is in the strong direction of the plate. The highest vertical baseplate force is {{ }}2(a),(c). Sufficient design margin is available to accommodate the increase in vertical baseplate force.

Table 3-58 Maximum fuel storage rack baseplate forces

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}}2(a),(c)

The maximum contact forces between rack baseplates to adjacent rack exterior faces are summarized and compared to the analyses with fully loaded racks in Table 3-59. The highest contact force is {{ }}2(a),(c) (X-direction, baseplate of Rack #13 to exterior wall of Rack #14). The increased forces are due to increased rack-to-rack impact. ; however, the fully loaded analyses have demonstrated that impact loadings are {{ }}2(a),(c) Design checks demonstrate Ssufficient design margin is available to accommodate the increase in contact force (See Section 3.1.6.7.3).

Response to Request for Additional Information
Docket No. 52-048

eRAI No.: 9013
Date of RAI Issue: 09/29/2017

NRC Question No.: 09.01.02-34

10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10 CFR 52.80(a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. SRP Sections 9.1.2 and DSRS Sections 3.8.4 Appendix D describe the specific SRP acceptance criteria for the review of the fuel racks to meet the requirements of the Commission's regulations identified above.

In Section 3.1.5.5.3 (pages 187-188), "Compression/Buckling" is addressed. The fuel tube and corner angle, treated as columns, are evaluated. Calculated compressive forces from the seismic + deadweight analysis are significantly less than conservative estimates of the elastic buckling capacity. However, the evaluation does not address local plate buckling of the fuel tube wall having thickness t, width d, and height l) at the bottom of the fuel tube, below the sheath for the moderator material. Because this has proven to be a critical location in other spent fuel rack designs, the staff requests that the applicant provide a quantitative evaluation for local plate buckling of the fuel tube wall.

NuScale Response:

To evaluate the local plate buckling of the fuel tubes, the critical buckling stress of the tube material under uniaxial loads is calculated. NUREG/CR-6322 provides guidance for buckling analyses of plate and shell elements and provides acceptance criteria for the use of stainless steel components. Section 6.5 of NUREG/CR-6322 states that Appendix F of ASME Subsection NF does not provide specific design rules for plate and shell type supports. The recommendation provided by NUREG/CR-6322 for Service Level D is for the compressive stresses to be limited to two-thirds of the value of the buckling load determined using critical buckling formulas in Section 5.0 of NUREG/CR-6322. Section 5.3, Equation (11) provides the theoretical buckling stress for a plate under uniaxial load:

$$\sigma_e = k_c \frac{\pi^2 \times E}{12(1-v^2)}\left(\frac{t}{b}\right)^2$$

Where,

σ_e = Theoretical buckling stress

k_c = Plate buckling coefficient (4.0 for simply supported)

E = Modulus of Elasticity

v = Poisson's Ratio

t = Plate thickness

b = Column width (taken as the inner width of the tube)

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}} 2(a), (c)

The maximum vertical reaction at a single support leg was found to be 162 kips. Considering the maximum single leg force is experienced by all eight legs of the fuel storage rack, and resisted by each of the 121 fuel tubes in the fuel storage rack:

Total Load: $162 \frac{\text{kip}}{\text{leg}} \times 8 \text{ legs} = 1296 \text{ kip}$

Load Per Fuel Tube: $\frac{1296 \text{ kip}}{121 \text{ fuel tubes}} = 10.71 \text{ kip}$

Fuel Tube Compressive Stress: $\frac{10.71 \text{ kip}}{3.92 \text{ in}^2} = 2.73 \text{ ksi} < 10 \text{ ksi} \rightarrow \text{OK}$

Impact on DCA:

There are no impacts to the DCA as a result of this response.

Response to Request for Additional Information
Docket No. 52-048

eRAI No.: 9013
Date of RAI Issue: 09/29/2017

NRC Question No.: 09.01.02-35

10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10 CFR 52.80(a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. SRP Sections 9.1.2 and DSRS Sections 3.8.4 Appendix D describe the specific SRP acceptance criteria for the review of the fuel racks to meet the requirements of the Commission's regulations identified above.

On page 193 of the report (as well as several other locations), the applicant provides the design of the welds. It appears that the weld stresses are checked separately for fv and fh against the code allowable stresses. The applicant should explain why the resultant weld stress due to the two perpendicular directions is not checked against code allowable values.

NuScale Response:

The original foot design used a force couple to convert horizontal loads to vertical components. The foot design and evaluation was re-examined and modified as a result of the re-examination. The general design is the same, but the support tube and screw block were modified. The outer diameter of the support tube and screw block were increased and the material used was changed to {{ }}$^{2(a), (c)}$. Also, the cylindrical center post was modified to use {{ }}$^{2(a), (c)}$ material.

The stress evaluations were performed for the support leg using two combined perpendicular directions. The resultant forces were used in evaluating the weld stresses against the code allowables.

The support leg evaluations performed in Section 3.1.5.5.2 and Section 3.1.5.5.3 of TR-0816-49833-P, were updated accordingly. See the end of this document for the TR markups of the complete evaluation.

Impact on DCA:

Technical Report TR-0816-49833, Fuel Storage Rack Analysis, has been revised as described in the response above and as shown in the markup provided in this response.

This impact energy is approximately 90 percent greater than that from the vertical shallow drop performed in the shallow-drop case. However, because the FA is {{ }}2(a),(c) long and the fuel cells are approximately {{ }}2(a),(c) wide, the horizontal assembly would come in contact with at least five cell partitions, while the vertical drop concentrated all of the impact energy to only one cell partition. Each cell partition is considered to provide the impact area of two inner grid plates and two fuel cell plates.

Therefore, a worst-case horizontal drop onto a fuel storage rack would generate less impact energy over the corresponding impact area than the vertical drop performed in the shallow-drop case (Section 3.1.3.6). Thus, the shallow-drop case analysis case bounds this load drop scenario and no additional evaluation is required.

3.1.3.6.6 Support Leg

The maximum axial force on the support leg for the $D + L + F_d$ load case is {{ }}2(a),(c), which occurs during a deep drop on the corner support leg.

The support tube welded directly to the baseplate would dampen the impact from the FA, transferring a lower impact force to the rest of the support leg. Therefore, the load obtained in the deep-load drop on corner is conservative. Any deformation or failure of a single support tube from drop-impact would not have an impact on the functional capability of the rack, as the configuration of the rest of the structure would remain intact. The load transferred to the pool liner would also not be affected. Thus, the support tube is not evaluated under impact loading.

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}}2(a),(c)

Figure 3—124 Support leg cross sections

The lower portion of the screw block (Section A-A in Figure 3—124), to which the support plates are welded, is loaded in shear due to the vertical loads transmitted through the support plates.

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}}2(a),(c)

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}}2(a),(c)

The upper portion of the baseplate (Section B-B in Figure 3—124), is also loaded in shear.

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}}2(a),(c)

Due to the size, number of threads, and configuration of the screw block, stripping the internal thread does not impact the functional capability of the rack.

3.1.3.6.7 Bearing Plate

The maximum axial force on the support leg for the $D + L + F_d$ load case is {{ }}2(a),(c), which occurs during deep drop on the corner support leg (Case 2B).

The bearing plate is loaded entirely in the shear plane beneath the leveling screw. The shear plane is considered as vertical through the thickness of the plate, providing the most conservative shear area.

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}}2(a),(c)

6. {{

}}2(a),(c)

7. {{

}}2(a),(c){{

}}2(a),(c)

3.1.5.3 Configuration, Initial Conditions, Boundary Conditions, and Limitations

1. Each of the rack models used in this analysis is based on the detailed model of the fuel storage rack discussed in Section 3.1.1, although finer meshes are used for each model. Thus, the same modeling simplifications are applicable for this analysis.

2. The built-up outer brace (midband) is simplified to an equivalent plate. The section modulus and cross-sectional area of the simplified member are compared to those from the actual member. Equivalency comparisons demonstrate the stress intensity in the simplified member should be multiplied by a factor of 3.0 for stress analyses.

3. The spacer bars contribute negligible stiffness to the rack and are not explicitly modeled.

4. FAs are not explicitly modeled; however, the density of the fuel storage tubes is modified to incorporate the mass of the FA. The FAs provide no structural function and have negligible effect on the stiffness of the rack. This simplification reduces elements and computer run times and is appropriate. Additional loads due to impact of the FA on the rack during seismic conditions are included in the displacement time histories from the whole-pool analysis as discussed in Section 3.1.4.

5. The bearing plates are not included in the finite elements models for deadweight and seismic analysis. Maximum loads are obtained at each support location in the model and are used to qualify the support leg by hand calculation. Because the support legs are free-standing, moment transfer to the bearing plates is negligible, and prying and bending effects in the plates are not evaluated.

6. The edges of the baseplate {{ }}2(a),(c) are not included in the simplified model in the whole-pool analysis (Section 3.1.4). This protrusion is approximately two inches. When mapped to the detailed model, displacements at these nodes are not included. Seismic inertia from this small region of the baseplate is negligible; therefore, this simplification is appropriate.

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}}2(a),(c)

}}2(a),(c)

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}}2(a),(c)

The maximum forces on the bearing plate are the same as those on the rest of the support leg. The shear plane is transferred to the bearing plate through the leveling screw. The shear plane for the vertical force is considered as vertical through the thickness of the plate at this location (conservative). The bearing plate uses material {{ }}2(a),(c) stainless steel that has a higher yield stress.

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~~}}2(a),(c)~~

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}}2(a),(c)

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}}2(a),(c)

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}}2(a),(c)

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}}2(a),(c)

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}}2(a),(c)

Welds

The welds between the lifting lugs and the corner posts, and the welds between the corner posts and the baseplate are conservatively analyzed as fillet welds. However, the welds are actually full-penetration welds. These connections undergo greater loading with a more conservative safety factor for the lifting analysis. Refer to Section 3.1.5.5.5 for that evaluation.

The welds connecting the bottom grid to the baseplate undergo negligible loading for these service levels.

All other welds used on the rack are full penetration or otherwise have an effective throat thickness equal to the width of the joined components; therefore, base metal allowables control. Further evaluations of these welds are unnecessary.

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}}2(a),(c)

Support Leg

The {{

}}2(a),(c) Additionally, the retainer plate, screw block, and the welds between the support tube and the baseplate and screw block are checked.

~~Per Section F-1334 of Reference 13, a factor equal to the lesser of 2 or 1.167S_u/S_y may be applied to the allowable stress values for Level A unless otherwise noted. For this evaluation, a factor of two is applied to the Level A allowable for welds. All other allowable stress values for this evaluation are shown in Table 3-26.~~

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}}2(a),(c)

Figure 3—142 Support leg detail

Maximum reactions at a single support leg are extracted from the whole-pool analysis. Two cases are selected as they have the potential for maximum combined stress.

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}}2(a),(c)

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}}2(a),(c)

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}}2(a),(c)

Figure 3—143 Shear forces on screw block

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}}2(a),(c)

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}}2(a),(c)

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}}2(a),(c)

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}}2(a),(c)

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}}2(a),(c)

This is less than the upward force calculated at the edge of the screw block and is less than the downward force of $0.5 \times F_Z$. Therefore, tensile stresses and prying effects in the screws of the retainer plate are negligible.

Per Section F-1334.10 of Reference 13, bearing stresses between the bearing plate and the cylindrical portion of the screw block are not evaluated for Level D loading.

The maximum forces on the bearing plate are the same as those on the rest of the support leg. The shear plane is transferred to the bearing plate through the leveling screw. The shear plane for the vertical force is considered as vertical through the thickness of the plate at this location (conservative). The bearing plate uses material {{ }}2(a),(c) stainless steel.

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}}2(a),(c)

The results above demonstrate that all components of the support leg meet the Level D acceptance criteria of Reference 13.

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}}2(a),(c)

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}}2(a),(c)

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}}2(a),(c)

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}}2(a),(c)

Welds

The welds between the corner posts and the baseplate are conservatively analyzed as fillet welds. However, the welds are actually full-penetration welds.

The welds between the lifting lugs and corner posts are evaluated as full-penetration welds. These connections undergo greater loading with a more conservative safety factor and lower allowable stresses for the lifting analysis in Section 3.1.5.5.5. In the lifting analysis, the lug weld is designed for a vertical load of 1200 lb. For Level D, a maximum vertical acceleration of {{ }}2(a),(c) would cause a vertical load of only {{ }}2(a),(c) on the weld. Other loads, such as inertia and water pressure, have a negligible impact on this weld. Thus, further evaluation of this weld is not required.

The welds connecting the bottom grid to the baseplate undergo negligible loading for these service levels.

All other welds used on the rack are full penetration or otherwise have an effective throat thickness equal to the width of the joined components; therefore, base metal allowables control. Further evaluations of these welds are unnecessary.

Spacer Grid Tubes

Seismic stresses in the spacer grid tubes are primarily caused by bending in the vertical direction under self-weight. Based on Level D loading (seismic), it is concluded that the spacer tubes meet the Level D acceptance criteria.

Enclosure 3:

Affidavit of Zackary W. Rad, AF-0118-58485

NuScale Power, LLC

AFFIDAVIT of Zackary W. Rad

I, Zackary W. Rad, state as follows:

1. I am the Director, Regulatory Affairs of NuScale Power, LLC (NuScale), and as such, I have been specifically delegated the function of reviewing the information described in this Affidavit that NuScale seeks to have withheld from public disclosure, and am authorized to apply for its withholding on behalf of NuScale.
2. I am knowledgeable of the criteria and procedures used by NuScale in designating information as a trade secret, privileged, or as confidential commercial or financial information. This request to withhold information from public disclosure is driven by one or more of the following:
    a. The information requested to be withheld reveals distinguishing aspects of a process (or component, structure, tool, method, etc.) whose use by NuScale competitors, without a license from NuScale, would constitute a competitive economic disadvantage to NuScale.
    b. The information requested to be withheld consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), and the application of the data secures a competitive economic advantage, as described more fully in paragraph 3 of this Affidavit.
    c. Use by a competitor of the information requested to be withheld would reduce the competitor's expenditure of resources, or improve its competitive position, in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.
    d. The information requested to be withheld reveals cost or price information, production capabilities, budget levels, or commercial strategies of NuScale.
    e. The information requested to be withheld consists of patentable ideas.
3. Public disclosure of the information sought to be withheld is likely to cause substantial harm to NuScale's competitive position and foreclose or reduce the availability of profit-making opportunities. The accompanying Request for Additional Information response reveals distinguishing aspects about the methods for structural design by which NuScale develops its fuel storage rack.

    NuScale has performed significant research and evaluation to develop a basis for this methods for structural design and has invested significant resources, including the expenditure of a considerable sum of money.

    The precise financial value of the information is difficult to quantify, but it is a key element of the design basis for a NuScale plant and, therefore, has substantial value to NuScale.

    If the information were disclosed to the public, NuScale's competitors would have access to the information without purchasing the right to use it or having been required to undertake a similar expenditure of resources. Such disclosure would constitute a misappropriation of NuScale's intellectual property, and would deprive NuScale of the opportunity to exercise its competitive advantage to seek an adequate return on its investment.

4. The information sought to be withheld is in the enclosed response to NRC Request for Additional Information No. 244, eRAI No. 9013. The enclosure contains the designation "Proprietary" at the top of each page containing proprietary information. The information considered by NuScale to be proprietary is identified within double braces, "{{ }}" in the document.
5. The basis for proposing that the information be withheld is that NuScale treats the information as a trade secret, privileged, or as confidential commercial or financial information. NuScale relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC § 552(b)(4), as well as exemptions applicable to the NRC under 10 CFR §§ 2.390(a)(4) and 9.17(a)(4).
6. Pursuant to the provisions set forth in 10 CFR § 2.390(b)(4), the following is provided for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld:
    a. The information sought to be withheld is owned and has been held in confidence by NuScale.
    b. The information is of a sort customarily held in confidence by NuScale and, to the best of my knowledge and belief, consistently has been held in confidence by NuScale. The procedure for approval of external release of such information typically requires review by the staff manager, project manager, chief technology officer or other equivalent authority, or the manager of the cognizant marketing function (or his delegate), for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside NuScale are limited to regulatory bodies, customers and potential customers and their agents, suppliers, licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or contractual agreements to maintain confidentiality.
    c. The information is being transmitted to and received by the NRC in confidence.
    d. No public disclosure of the information has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or contractual agreements that provide for maintenance of the information in confidence.
    e. Public disclosure of the information is likely to cause substantial harm to the competitive position of NuScale, taking into account the value of the information to NuScale, the amount of effort and money expended by NuScale in developing the information, and the difficulty others would have in acquiring or duplicating the information. The information sought to be withheld is part of NuScale's technology that provides NuScale with a competitive advantage over other firms in the industry. NuScale has invested significant human and financial capital in developing this technology and NuScale believes it would be difficult for others to duplicate the technology without access to the information sought to be withheld.

I declare under penalty of perjury that the foregoing is true and correct. Executed on 1/31/2018.

Zackary W. Rad